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DYNAMICS OF EVOLUTION.

The Origin and Evolution of Life on the Theory of Action, Reaction, and Interaction of Energy. By Prof. H. F. Osborn. Pp. xxxi + 322. (London: G. Bell and Sons, Ltd., 1918.) Price 25*s.* net.

"CONFESSION of failure," Prof. Osborn writes, "is part of the essential honesty of scientific thought." Wave after wave of evolutionary theory has prompted research, but, in spite of many new facts, there has been little fresh enlightenment since Darwin's day. "The chief causes of the orderly evolution of the germ are still entirely unknown." So the author has sought for a fresh starting-point—"an energy conception of evolution." He would take the organon of physico-chemical science for a while, leaving morphology and bionomics to the end. There are four main complexes of energy to be considered — the inorganic environment, the organism, the heredity germ, and the animate environment. How are they adjusted to one another? What in particular are the relations of the heredity germ with the other complexes, for are we not slow to learn Weismann's lesson that the essential question is as to germinal evolution, not as to bodily evolution? The heredity germ remains inconceivable as regards its development, its lineage, and its evolution. Thus, in his preface, Prof. Osborn cleans the slate. His essential honesty is a little depressing, but the general idea is: We have been thinking too much from Form backwards; let us try to think from Energy forwards.

Organisms as material systems are solidary with the inorganic, but they are distinguished by their more dominant constructive capacities, as Joly pointed out very clearly long ago. Besides the actions and reactions (capturing, storing, releasing energy) which conform to the second law of thermodynamics, there is in organisms a distinctive dominance of "interactions" which unify or integrate—*e.g.* nervous impulses or chemical messengers. "Interaction" has to do with the co-ordination, balance, co-operation, compensation, acceleration, and retardation of actions and reactions. In the course of development there is evidence of this correlating and regulating, which Prof. Osborn is not felicitous in calling "the directing power of heredity." The central thought of the book is thus stated: "In each organism the phenomena of life represent the action, reaction, and interaction of four complexes of physico-chemical energy, namely, those of (1) the inorganic environment, (2) the developing organism (protoplasm and body-chromatin), (3) the germ or heredity-chromatin, (4) the life environment. Upon the resultant actions, reactions, and interactions of potential and kinetic energy in each organism selection is constantly operating wherever there is competition with the corresponding actions, reactions, and interactions of other organisms." The author is quick to add that, "while this is a principle which largely governs the organism, it remains to be discovered whether it also governs the causes of the evolution of the germ." This is Prof. Osborn's "tetrakinetic" or "tetraplastic" theory.

The constructive part of the book opens with an interesting discussion of "the preparation of the earth for life," the capture of the sun's heat and light, the suitability of various elements to function in metabolism, and similar topics. As to the primary physico-chemical stages of life, the following steps are speculatively suggested: The assemblage of several of the ten elements now essential to life, the integration of these in a novel way ("a new form of unity in the cosmos") and in a state of colloidal suspension, the appearance and specialisation of catalysers (effecting biochemical co-ordination and correlation), the beginning of competition and natural selection. What primordial life-forms competed about we are not told; probably for a place in the sun. The attractive agency of hydrogen and oxygen led to the incorporation of additional elements useful in energy-capture. But no great progress was possible until interactions were established which regulated and unified metabolism; and a vivid account is given of the variety of chemical messengers, both general and specific, which play so important a *rôle* in the economy of the organism.

Prof. Osborn then passes to consider bacteria as the forerunners of ordinary plant and animal protists; they show the capture, storage, and utilisation of energy in simplest expression; they form the primordial food supply; they lead on to the first true cells with differentiated protoplasm and chromatin. Through the chromatin, excelling all other substances in the complexity of its molecular constitution, it became easier for an organism to retain its integrity amid ceaseless metabolism and from generation to generation. Another great step with incalculably important results was implied in the appearance of chlorophyll, which hitched organisms in a new way to the sun, facilitating energy-capture enormously.

In the second part of his book Prof. Osborn deals with the evolution of animal form, and proves himself an entertaining and illuminating guide. What seemed to us in earlier pages an over-emphasis on the adequacy of physico-chemical formulations is now corrected by a recognition of psychic powers which are in an indirect way "creative of new form and new function." In the vivid sketch of the evolution of vertebrates there are very valuable features, notably (*a*) the correlation of organismal and environmental changes; (*b*) the illustration of adaptive radiation of group after group to the twelve chief habitats; (*c*) the continual facing of the difficulty that, unless one is a thoroughgoing Lamarckian, the sources of the raw materials of evolution must be looked for in the heredity germ, not in the organism; in the genotype, not in the phenotype; (*d*) the recognition of the simultaneous and cor-

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related evolution of a multitude of characters in one organism (which is aptly likened to an advancing army with units, companies, and regiments); (*e*) the importance of what we venture to call temporal variations—*i.e. plus* and *minus* changes in the rate or *tempo* of the evolution of various parts of the body, which may perhaps be correlated with variations in glands of internal secretion; (*f*) the insistence on the palæontological evidence, which has accumulated since Waagen's day, thanks in great part to Prof. Osborn's own industry, that the evolution of characters often proceeds by minute and definite changes; and (*g*) what we confess to having an incorrigible pleasure in welcoming, an admission that the "initiative" of the organism counts. Prof. Osborn's concept of "interaction" does not seem to us to differ from the concept of "correlation" or "integration" with which many of us have worked, but perhaps he has done more justice to it than have others. At any rate, his clear view of the dynamical aspect of the organism has resulted in an uncommonly fresh and stimulating book which will make many students of biology grateful. We wish we had space for more than a word of praise for the abundant illustrations, which are very original and telling.

J. A. T.

EXPERIMENTS IN BIOLOGICAL METHOD.

(1) *The Quantitative Method in Biology.* By Prof. Julius MacLeod. ("Publications of the University of Manchester," Biological Series, No. 11.) Pp. xii+228. (Manchester: University Press; London: Longmans, Green, and Co., 1919.) Price 15*s.* net.

(2) *A Text-book of Biology. For Students in General, Medical, and Technical Courses.* By Prof. William Martin Smallwood. Third edition, enlarged and thoroughly revised. Pp. 306. (Philadelphia and New York: Lea and Febiger, 1918.) Price 10*s.* 6*d.* net.

AT intervals, in every science, investigators and teachers begin to become dissatisfied with accepted methods. They come to realise that the methods in vogue were adapted to a certain stage in the development of the science, and that as the science progresses changes both in the means of investigation and in the manner of teaching become needful. The two books under review have one feature, and perhaps only one, in common; they both are attempts to introduce improved methods, the one in investigation, the other in teaching.

(1) Prof. MacLeod, of Ghent, while resident at Manchester, has continued his studies on what might be called biometry were not his methods so different from those of the English school of biometricians, and expounds his aims for the benefit of British readers. He tells us that in the physical sciences "the properties of objects are measured and expressed by means of figures called *constants*," while in biology "the properties (characters) of the living things are usually described by means of terms" (long, short, narrow, oval, etc.). "The object of the present book is to describe a method by which biological constants may be established." He begins by assuming that there is a chemical basis for species, for the living basis of each species is a mixture of chemical substances, and these specific mixtures differ from one another by at least one entity. Species are thus essentially discontinuous, but every specific property is the resultant of a reaction between the specific mixture and environmental forces. Hence arises *plasticity*—the variation of species due to environmental differences. Variation due to plasticity and that due to germinal change can be investigated adequately only by quantitative methods, as is recognised by both the biometric and Mendelian schools. But exact methods are needed, especially in systematic biology, and also in embryology, comparative anatomy, and physiology, and it is suggested that many new facts and ideas would come to light if this were more generally recognised. For this purpose the author seeks in each species investigated a number of simple properties, analogous with Mendelian unit characters, which can be observed and recorded accurately. These he calls *primordia*, and they are such that each is the expression of a state of equilibrium at the time when it is observed, though it may disappear or change to a different primordium later. For example, the petals of the forget-me-not are first white, then pink, then blue; white and pink are transitory primordia, blue is persistent. Most primordia chosen are measurable—lengths, numbers of segments, and so forth—but such features as colour or texture may also be used.

By means of the study of such primordia, made by the author chiefly in plants and insects, a number of principles are deduced, with which all biologists are familiar in an indefinite sense, but which are rarely expressed in a concrete form. Of these may be mentioned especially *gradation*, defined as the variation of a given property along a given axis (as, for example, the lengths of successive internodes in plants), and also a number of curious and ingenious comparisons between organic variation and the numerical results of chance in regard to the tossing of coins, throwing of dice, etc.

The main aim of the book, however, is to show that by making sufficient measurements of independently varying "primordia" true biological constants are obtained. For if a sufficient number of specimens are examined (and the author shows that this number need not be excessively large), the maximal, and sometimes also the minimal, value of each primordium is "a strictly determined biological constant," so that a collection of such constants is not only an adequate and easily used diagnosis of the species, but may be used also for the study of development, comparative anatomy, and the influence of environment (plasticity) Though the book contains much that is

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